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THE LOWELL OBSERVATORY ECLIPSE OBSERVATIONS, JUNE 8, 1918.

PROMINENCES AND CORONAL ARCHES.

BY C. O. LAMPLAND.

(Read April 25, 1919.)

The solar prominences or protuberances have considerable historical interest in the part they have taken in the advances made in our knowledge of the constitution of the sun. These beautiful formations, varying in color from deep ruby to pale pink, projecting outside of the dark disk of the moon upon the background of the pearly luster of the corona at times of totality caught the attention of earlier observers and we may have references to them extending back two hundred years. They came to occupy a conspicuous place in the eclipse literature of 1842, and Dr. Lockyer remarks of this eclipse in connection with the prominences, "then the golden age begins." But whether they belonged to the moon or the sun was a question that was not definitely decided until De la Rue's photographic observations of the eclipse of 1860. His series of exposures during totality showed beyond doubt that the prominences on the opposite edges of the sun were progressively covered and uncovered by the disk of the advancing moon. At the present day it may help us to sympathize with the difficulties of these earlier investigators to recall our own helplessness, and how we are apparently marking time, on some of the outstanding problems of the corona.

Our knowledge of the more complex structure of the inner corona by direct observations has been largely obtained by photography, and noteworthy progress has been achieved during the last twenty-five years. Large-scale photographs, suitable sensitive plates, and graduated series of exposures may be mentioned among some of the things that have contributed to the advances made.

In the present paper a brief account will be given of some preliminary observations of the prominences, of coronal formations over them, and of some of the complex structure of the inner corona, shown in the series of photographs obtained by the Lowell Observatory Eclipse expedition stationed at Syracuse, Kansas.

The photographs were made with two of the historic "Transit of Venus" objectives kindly loaned by the U. S. Naval Observatory. These objectives have an aperture of five inches and a focal length of 38.7 feet. They were mounted according to Schaeberle's method. The tower camera and its moving plate carrier have been so frequently described, and the method is so well and favorably known among astronomers that no time will be taken here for the description of the apparatus.

In connection with the description of some of the detail in the Lowell Observatory photographs quotations and illustrations from published observations of earlier eclipses will also be given, but such references must necessarily be very brief and incomplete at this time. It is thought that these comparisons should be both interesting and instructive.

A brief description will now be given of the more interesting features of the Lowell Observatory photographs.

P.A.	Description of Detail.
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25°	A coronal arch. No prominence visible.
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30°.5	Brilliant short prominence.
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51°.5	Large brilliant triangular-shaped prominence, base resting on chromosphere. Fine series of coronal arches, four or more, over this great prominence. Branches of the higher arches not symmetrical with respect to prominence but as if partially superposed from perspective displacement.
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99°.5	Small bright prominence inclined (N. and W.) to solar surface about 45°. It is centrally in great mass of brilliant coronal matter. Indications of arches but detail cloud-like or flocculent in parts.
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- 162°. A group of three brilliant prominences near south pole;
to positions of centers of these prominences about 165°,
182° 172°.5, and 179°.5 (position of south pole of sun 167°.4).
Very bright coronal matter over the group. Strong hood
or arch over the first two prominences; part of an arch over
the third (named in order of increasing P. A.).
- 186° A large bright "petal" of coronal matter over the brilliant
to flame-like prominence in position angle 205°. A closely
226° packed series of arches, all of the pointed or ogival type,
except possibly the inner one. At least six of these arches
stand out distinctly. The highest ones very sharply
pointed, and the apexes, with increasing height, are to one
side of the center of the prominence, as though the dis-
placement were an effect of perspective.
- 231° Another large brilliant "petal" of coronal matter, with the
to great eruptive prominence centrally in its base (P. A. of
270° center of prominence about 251°). At least five arches are
visible. In this instance the arches are oval curves, and not
pointed at the vertices. The arches are somewhat skewed,
the inclination being in the same direction as the trunk of
the great skeleton prominence they enclose. A comparison
of the Lick and Lowell plates shows marked changes in
the eruptive prominence.
- 233°.5 Base of the "rocket" prominence.
The higher part of the trajectory of this eruptive forma-
tion or jet is not certainly shown on the Lick plates taken
about 27^m earlier. On the Lowell plates the upper part
of the curve is clearly shown and the brilliant nucleus has
apparently passed its greatest height and is descending.
- 270° Very brilliant "petal" of coronal matter, with large bril-
to liant prominence centrally (P. A. of base of prominence
320° extends from 288° to 301°). Complex detail above the

prominence—cloudy and flocculent— with indications of confused and overlapping arches.

- 351°.5 Prominence near the north pole.
225° Pronounced rifts in the corona occur near these points,
and the latter inclined, near limb, 20° or more southward with
270° the radius.
- 35° Four narrow and well-defined dark rays in brilliant coronal
to matter, inclined a few degrees, northward, with the radius
40° where rays start from the limb, but with gentle bending
southward towards the equator with increasing distance
from the limb. A number of broader and more diffuse
dark lanes and streaks occur in different parts of the corona.

Any detailed description of the appearance, distribution and directions of the coronal rays for different regions will not be given here. The variability and irregularity of their inclinations with respect to the limb of the sun suggests the maximum type of corona, though in some other respects characteristic features of the intermediate type are present, as for example the general shape of the corona as a whole is roughly triangular.

In the Lowell Observatory photographs all of the prominences except the one near the north pole are surrounded by arches or envelopes or of disturbed coronal matter. Above some of the prominences there are series of hoods or arches the forms of the inner or lower ones being generally some oval curve, while the outer or higher ones have forms resembling the pointed or ogival arch.

One striking feature of these photographs is the disturbance of the coronal streamers at and in the vicinity of the sun's poles. In that respect the corona of 1918 resembles earlier ones observed near sun-spot maxima, though as previously remarked it exhibits other features characteristic of intermediate types. In the present photographs it would be difficult to estimate the position of the poles of the sun from the appearance of the streamers.

That there is an intimate relation between the prominences and the surrounding coronal structure has at different times been ex-

pressed by observers of the more recent eclipses. But these relations are not always evident as will be shown by extracts from published observations of eminent observers and students of eclipse phenomena. It is probably true that hoods and envelopes over the prominences are generally present but are greatly reduced in intensity or may even be absent for a short time near sun-spot minima and it is also probably true that such detail and complex structure in the inner corona are generally conspicuous at times of greater solar activity.

From an extensive examination and careful study of many photographs of the corona beginning with the eclipse of 1851 and continuing with the later eclipses of 1860, 1870, 1871, 1875, 1878, 1882, 1883 and 1885, an eminent authority on eclipse photographs writes: "There is no sign of any connection between the coronal rays and the solar prominences." It would seem, however, that the present trend of the interpretation of observational results is that the prominences generally do affect to a marked degree coronal structure in their vicinity.

The complex coronal structure, arches, etc., of the eclipses of 1871, 1883, 1893, 1905 and 1918 occurring at or near times of sun-spot maxima, and the almost complete absence of such intricate and complicated detail of the lower regions of the corona of the eclipses occurring at or near the minima of sun-spot activity in 1878, 1889 and 1900 may be mentioned in this connection. The eclipses at the minimum epochs were so fully and so successfully observed that it is difficult to believe that such structure could have been overlooked. The reports for 1900 by Hale, Langley, Newall, Wesley and others are especially complete in this respect as specific mention is made with reference to search for such detail. It also appears from the observational results that the complex detail in question is present in varying degrees for eclipses observed preceding or following minima of solar activity. The eclipses of 1896 and 1898 are good examples of eclipses that fall between a maximum and minimum.

The question of changes taking place in detail in the corona in the interval between observations made at different stations is one of great interest and we are not aware that a definite answer

has yet been given in the previous attempts to decide the matter. It was hoped that it might have been possible to include some satisfactory observations in this communication. The preliminary work done thus far does not warrant a stronger statement than to say that further comparisons should be made, at least in the case of one of the series of prominent arches. Unfortunately the material at present available is not wholly satisfactory for such difficult comparisons. As prominence detail is frequently subject to rapid change it does not seem worth while to add anything further than already given relative to such comparisons. The marked changes that occurred in the great eruptive prominence are obvious upon casual inspection.

Our appreciative thanks are due to Dr. Campbell for generously granting permission to make use of three very fine positives from plates of short exposure taken at Goldendale, sent us recently.

Dr. Slipher gives herewith a summary of his observations of the spectrum:

SPECTRUM OBSERVATIONS OF THE CORONA.

The spectrograms recorded a strictly continuous spectrum for the inner corona crossed by the three coronal emissions of wavelengths 4086, 4231 and 5303.0; and a faint solar dark-line spectrum for the outer corona which seems to be of true coronal origin. The objective prism plates registered the continuous spectrum of certain prominences in addition to their usual emissions, and the green coronium ring between the fragmentary ones of hydrogen F and helium D₃. The distribution of the intensity of the green ring implies that the substance "coronium" is generally abundant along those parts of the sun's limb occupied by prominences and from which flow the great extensions of the corona, and that it is sparse along those sections of the limb occupied by the bristling streamers typical of the polar regions.

The observational results given in the present paper are the joint work of Dr. V. M. Slipher, Mr. E. C. Slipher and the writer. A general account of the organization and work of the expedition has been published in one of the astronomical journals.

LOWELL OBSERVATORY,
FLAGSTAFF, ARIZONA.